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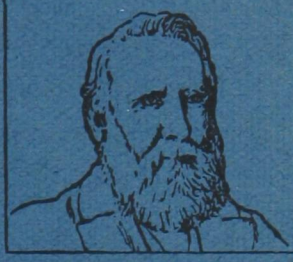

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THE METEOROLOGICAL MAGAZINE.

No. 681
OCTOBER 1922
Vol. 57

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OCTOBER, 1922.

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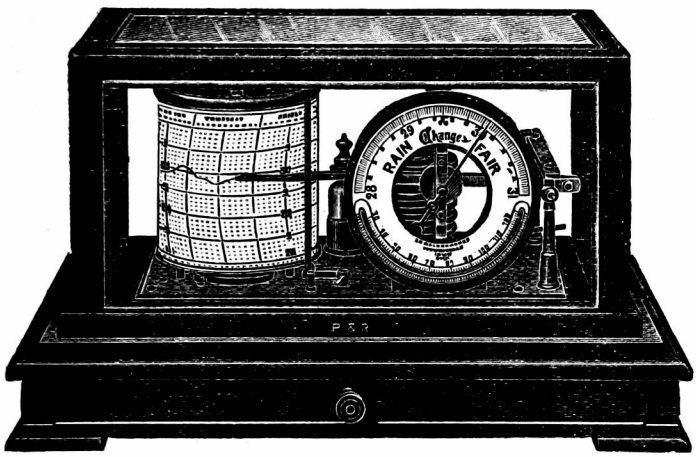

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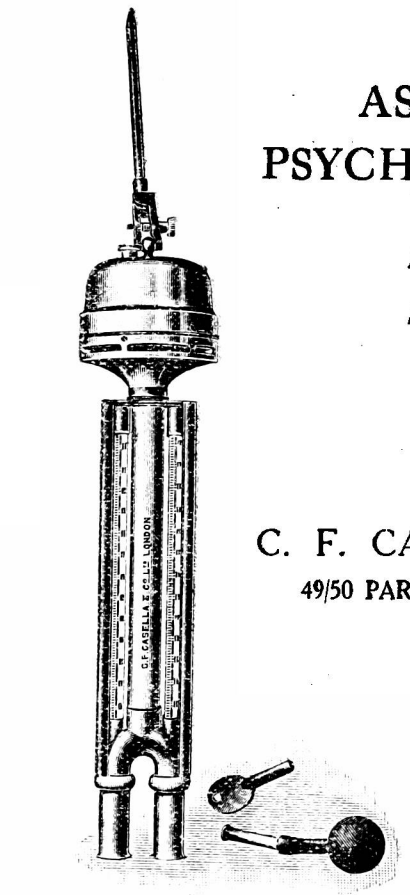

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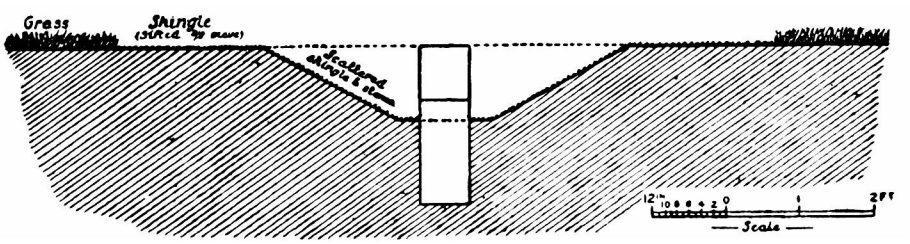
Exposure of Rain-gauges.

BY Lt.-Col. E. GOLD, M.A., F.R.S.

THE effect of exposure upon the catch of a rain-gauge is known to be important, but there is little precise information about the magnitude of the effect,* partly owing to the difficulty of securing a proper standard with which to compare the record from a gauge which is unduly exposed to strong wind.

Some ten or twelve years ago I put forward a suggestion for having a rain-gauge placed in the centre of a circular hole, but it was not until the early part of 1922 that an experiment of this character was made, owing to the initiative of Mr. L. H. G. Dines, at Valencia Observatory, where the 8-inch gauge hitherto



in use is placed in an open field. A conical hole, about 5 feet in diameter and 1 foot deep, was dug in the same field and a similar rain-gauge was placed in the centre of the hole so that its upper rim was practically on a level with the general surface of the ground. The object of placing the gauge in a hole was to shield the gauge from the strong wind without shielding it

* Various modifications of gauges have been suggested to avoid the direct effect of high wind; one of these is the Nipher gauge.

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from the rain and at the same time to prevent water running or splashing into the gauge from the surrounding ground. The cross-section of the hole is approximately that shown in the accompanying figure.

The result of the experiment shows that during a period when the ordinary 8-inch rain-gauge caught 335 mm. the gauge in the hole caught 387 mm., an excess of about 15 per cent. The deficiency of the gauge in the ordinary exposure might have been attributed to the effect of the wind, but it was clear from an examination of the rain caught in the gauge in the hole that there had been insplashing in spite of the precautions taken against it. The water caught was very dirty indeed: on one occasion small stones were found in it.

It is clear that the effect of insplashing upon the catch of a gauge placed in a hole, such as that at Valencia, will increase as the wind increases, because the result of an increase of wind will be to reduce the effective distance between the level ground and the gauge. This may account, at any rate in part, for the fact that the difference at Valencia between the two gauges is 15 per cent., whereas in the experiments described in *British Rainfall* 1865, made at Calne in Wiltshire, the difference was only 5 per cent. Partly also the difference is no doubt due to the sloping side of the hole at Valencia: an approximately vertical side would be preferable.

It appears clear that insplashing is more important than had hitherto been supposed and that even with gauges whose rims are one foot above the level of the ground, we cannot be sure that the amount of water splashing into the gauge can be neglected.

If the amount of water per unit time passing downwards across unit area (1 cm.^{2}) of a horizontal plane at a height above the ground sufficient to make certain that no water which has splashed from the surface of the ground reaches it, say 100 metres, is M grams per second, then the amount of water passing downwards across unit area of a horizontal plane near the surface of the ground, will be $M + m$ grams per second, where m is a function of height decreasing upwards: m will depend upon the nature of the surface of the ground, upon the size of the falling drops and upon the wind, and especially upon the turbulence of the wind. In a high wind the relatively fine spray from the splashing drops will undoubtedly be carried upwards to heights of 10, 20 or 30 metres. If we assume the surface of the ground to be uniform over a large area, then the value of m must necessarily be always positive. It is, of course, balanced by an equal rate of transfer *upwards* of the splashing water in the absence of any obstacles to the contrary, so that the *net* transfer downwards across unit area of a horizontal plane is M grams per second everywhere; but it is to be remarked

that if we interfere with the upward motion across the horizontal plane and allow only downward motion, as we do with an ordinary rain-gauge, then there is no balance effected and the catch of the gauge will be the integrated value of $M + m$ and not the " true " rainfall, the integrated value of M.*

Two ways of avoiding the effect of m with a view to arriving at an accurate standard suggest themselves, but it will be seen that difficulties and objections can be raised against them. One is to place the gauge at such a height, say 100 metres, as to prevent any risk of the value of m differing appreciably from zero. The other method is to have the gauge itself covered with the same surface as the surrounding country, so that conditions are uniform over the area in which the gauge is situated and the amount of water which splashes into the gauge is exactly balanced by the amount which splashes out. Such uniformity is not easy to attain when, as in this case, it is necessary to ensure that the water falling on to the surface within the circumference of the gauge must be free to run down into the collecting can. It might be approximately achieved by having shingle of uniform size over the area in which the gauge is placed and filling with the shingle a wire tray fitting into the top of the gauge. It might also be achieved by having a fine-mesh wire netting placed horizontally, or supported, at about 1 foot above the ground with the rim of the rain-gauge just touching the wire. The area of the gauge should be large (*i.e.*, at least 100 times) compared with the area of a mesh. It is clear that in a windy region the area over which uniformity is necessary must be considerable in extent, because wind may carry the spray from the splashing rain many tens of yards.

It might appear simpler to attack the problem by putting a rain-gauge on the top of a high mast such as a wireless mast, and arriving at a standard in that way; but here we meet with the difficulty that the wind blowing past the gauge causes an unsymmetrical distribution of eddies, which interfere with the amount of rain caught. The air moving upwards from the windward side of the gauge may not carry up with it the drops of rain, but it may be sufficient, as it moves across the top of the gauge, to carry out the rain drops which it receives in its progress.

This question of the exposure of the rain-gauge is one of practical importance; our knowledge of it is inadequate and it is a question which can be tackled at one place by an amateur meteorologist, especially if he lives in a wet and windy place. I do not suggest that he can obtain a complete solution, but he may, at any rate, contribute to the solution of a problem which appears

* It should be noticed, however, that evaporation from the falling rain will act in the opposite direction to m and tend to decrease the quantity crossing a horizontal plane as the level of the plane falls.

to have been very nearly neglected during the last 50 years and I therefore commend it to the attention of meteorologists who are seeking for an avenue of useful work in this subject.

As *British Rainfall*, 1865, is not perhaps readily available I give the following extracts relating to the experiments at Calne, which extended up to a height of 20 feet above the ground:—

ISOLATED SUNK GAUGE.—The rain caught at Calne, in 1864, in a gauge whose mouth was level with the surface of the earth, was about 5 per cent. greater than in that whose mouth was 1 foot above it; it was suggested that it might arise from insplashing, in support of which the frequency with which earth and small gravel are found in gauges so sunk was mentioned. In order to ascertain if this was the whole or partial cause, Colonel Ward has had a gauge sunk in a small pit so that it is level with the ground, but the earth being removed for some distance round it, no insplashing can occur. This has only been at work nine months. The result during that period has been—

	Total in.	Excess above fall at 1 ft.
Gauge at 1 foot above ground -	23·08	0·00
,, 6 inches ,, -	23·24	+ 0·16
,, 2 ,, ,, -	23·61	+ 0·53
,, level with the ground	23·91	+ 0·83
,, isolated and level with the ground - -	23·60	+ 0·52

For the year 1865 the following table shows total amounts collected in a gauge placed at different heights above the ground.

Height above ground.	Calne, Wilts.	Greenwich Observatory.	Manchester.	
			8 in.	5 in.
	in.	in.	in.	in.
Level	32·29	—	—	—
2 inches	31·97	—	—	—
5 ,,	—	28·67	—	—
6 ,,	30·76	—	—	—
1 foot - -	30·43	—	33·71	33·83
2 feet - -	29·81	—	—	—
3 ,, - -	29·88	—	—	—
5 ,, -	29·45	—	32·06	31·48
10 ,, - -	28·91 ?	27·69	—	—
20 ,, -	28·88	—	30·27	29·48
38 ,, - -	—	22·20	—	—
51 ,, - -	—	19·09	—	—

Further experiments are described in *British Rainfall*, 1867 and 1871. At Strathfield Turgiss, near Reading, a gauge on a post at a height of 20 feet recorded about 7 per cent. less than a gauge 4 inches above the ground during the four years 1868–1871. At Rotherham in one year, a gauge, 20 feet above the ground recorded about 10 per cent. less than a gauge 1 foot above ground.

[The percentage decrease in the case of gauges placed on the windward side of a hill slope, compared with gauges on level ground in the neighbourhood, is much greater than the decrease with height: on the lee side the fall is greater than on level ground. This may be a refraction effect: the "rays" of falling raindrops being "refracted" away from the vertical on the windward side and towards the vertical on the lee side.]

I may also add that the late Dr. Buchan wrote a short paper on "a protecting wire screen for the rain-gauge," in the *Journal of the Scottish Meteorological Society*, Volume IV. After discussing the effect of a net in reducing motion of the air, he says:—

> "Suppose then, a shallow pit fully a yard in diameter, made in an open grass plot, and a wire screen with meshes an inch wide laid over it, so that the screen will be exactly on a level with the grass plot. In the centre of this pit place a rain-gauge having its rim about an inch below the wire screen. Since the grass plot and the wire screen are at the same level, and since the wind has no access to objects under the screen, the rain-gauge will thus be protected from eddies of wind or other disturbing currents. By this arrangement the errors in observing the rainfall arising from eddies will be eliminated. The diameter of the pit is proposed to be made large, in order that the insplashing and outsplashing of the rain-drops, as they break on the wires of the screen, may counterbalance each other. The error due to the wetting of the wires, being practically a constant quantity for every time the wires are wetted, may be approximately ascertained and allowed for. It is scarcely necessary to add that the screen itself will require to be kept horizontally over the pit."

Meteorology at the British Association Meeting at Hull.

THE meeting of the British Association at Hull was well attended and the programme contained a number of items of geophysical interest. The meteorological arrangements outlined in the last issue of this Magazine were successfully carried out, thus maintaining the meteorological activity

revived at the meeting in Edinburgh last year, after the lapse during the war.

Prior to the meeting, Dr. G. C. Simpson, F.R.S., was elected a vice-president of the Mathematical and Physical Section (Section A). This recognition of the subject will be welcomed by all meteorologists.

Sir Napier Shaw's paper on "Convection in the Atmosphere" was a study of certain atmospheric processes based upon the consideration of meteorological observations in relation to laboratory experiment.

The atmosphere is endowed with a certain stability or vertical resilience in consequence of the normal distribution of potential temperature. Successive layers can slide one over the other, but preserve their separate identity. In relation to the facilities of motion the atmosphere is like a pack of cards.

There are three physical processes which overcome this natural stability and cause the relative displacement of air-masses upwards and downwards in spite of the layering. One of these processes is eddy motion due to frictional or viscous forces. It carries upward the air of the surface (which is normally relatively moist) and may cause cloud or drizzling rain. A second is the well-recognised flow of air across the isobars at the surface. The effect of this flow is, on the one hand, to let down the general mass of air within an anticyclone at the rate, perhaps, of 80 metres per day, and, on the other hand, to pile up air over the area of a cyclone at the rate of about 80 metres per hour. This process used to be regarded as controlled by thermal convection and, therefore, as pointing to the cause of maintenance of low pressure; on the contrary, it should be regarded as the natural method of annihilating cyclones. It would invariably succeed if there were not some means of renewing the energy.

The third process is true thermal convection by which the lower air penetrates the layers above it in virtue of its own levity, aided by the facility for condensing its moisture on cooling. The process is expressed by a column of air pushing upward and expanding as it rises. It may produce sudden and heavy rain.

A rainfall at the rate of 1·5 mm. per hour, giving 1·5 in. per day, is provisionally suggested as the lower limit of convective rainfall; below that the rainfall is eddy rainfall or cumulative rainfall.

The exceptional nature of thermal convection was illustrated by examples of pillar clouds and led to the question of the ultimate nature of the process; whether it was analogous to that of air in water which comes up as a multitude of small bubbles, a fine mixture of the air and the water. Stress was

laid on the peculiar importance of this form of vertical motion because of its evictive action. In its rapid ascent it carries along many times its own volume of the air through which it travels and causes dynamical effects not yet fully explored, but certainly important.

In the paper by Dr. J. S. Owens on "Atmospheric Dust," a short description of the jet apparatus for obtaining dust counts from the air was given and the principle upon which the instrument operates described.

The instrument depends for its effectiveness upon the reduction of pressure, and consequent condensation of moisture, brought about in a ribbon-shaped jet of air, which is caused to impinge upon a microscope cover-glass at a very high velocity. The dust particles adhere to the cover-glass by virtue of the condensed water and remain when the water evaporates. The nature of the record obtained is a linear deposit of dust 10 mm. long; 50 cc. of air are used for obtaining a dust count and if it is desired to examine for soluble salts a larger volume, about 1,000 cc., is used, when the salts dissolved from the dust in the condensed water re-crystallise on the cover-glass.

The nature of the dust was discussed and the methods of examination and counting. Reference was also made to records which showed practically no dust but a large number of crystals of common salt.

The practical bearings were considered; a means for examining the quantity and nature of atmospheric dust was shown to be necessary in the study of visibility, for the testing of air-purifying plant, and in connection with a study of the various dust diseases, such as silicosis. There is also a bearing upon the question of fog production by the condensation of water, and upon hygroscopic nuclei.

The sources of dust were next considered and the discovery of spherical transparent particles in the air was described. The number of these spherical particles varied greatly from time to time, but in a record taken on March 16th, 1922, at Westminster, 50 per cent. of the particles were spherical and many colourless and transparent, with a diameter up to 1·5 microns. The possible origin of these spherical particles was discussed and it was found that they were not soluble in water, xylol or oil, and did not stain. They were too small to be micrococci or pollen grains, and it was thought that the most likely source of such particles was volcanic, although they may possibly be of solar or cosmic origin. The question has not yet been definitely settled.

Records of dust found in the atmosphere at different places were mentioned as follows :—

1922.		Particles per cc.
September 2	Holme, Norfolk. Sea coast	152
,, 5	Brighton	1,380
,, 10 (Sunday)	Hull	3,080
,, 11 (Monday)	Hull	13,800
,, ,,	Hull (seaward of Spurn Head)	140

A fundamental difference between the dust-counter described and Aitken's is that, in the former, dust particles are examined under a high power and water drops are not taken into account, as all water has evaporated from the record before examination. In Aitken's dust-counter the only particles counted are water drops, in each of which a dust nucleus is assumed to be present, although invisible, since a low power objective must be used.

The weather charts and forecasts exhibited daily by the Meteorological Office were again widely appreciated. The reception by wireless of data messages and the subsequent steps in the preparation of the forecasts were witnessed by a very large number of visitors, and much interest was displayed in meteorological work generally. The paper read by Mr. M. A. Giblett before Section A contained a general description of this demonstration, followed by an outline of the present organised use of wireless telegraphy in collecting weather information at the Air Ministry, and in distributing data and forecasts. The facilities thus existing for the daily construction of current weather charts in universities and other educational institutions was pointed out, and emphasis laid on the value of this work, both from the educational point of view and as an aid to the appreciation of forecasts. Reference was made to the development of the New International Code, which embraces the more detailed meteorological information taken into account in modern forecasting, and also to the general lines on which forecasting is progressing, exemplified particularly by the generalisations of the Norwegian school of meteorologists.

Reports were made by the Committees for the Investigation of the Upper Atmosphere, for Seismological Investigations and for assisting work on Tides. The first indicated steps taken towards securing wide co-operation in the study of the upper air, in particular the investigation of the generality of the high correlation coefficients relating to temperature variations in the middle layers of the atmosphere, derived from Mr. W. H. Dines's observations in England. The provision of suitable instructions for observations with pilot-balloons of long-carry, both on land and sea, is also under consideration. The second

report, drawn up by Prof. H. H. Turner, was noteworthy for an account of a very recently discovered and well supported earthquake periodicity of slightly over 21 minutes. The third report mentioned that the meteorological effects on tides at Newlyn, Liverpool and other places have been under consideration this year at the Tidal Institute, Liverpool.

Other events included a "Citizens' Lecture" on "The Earth's Magnetism" by the Rev. A. L. Cortie, S.J., and a lecture to Section A, by Prof. J. Proudman, on "Tides, with special reference to the North Sea." The proceedings of the Geology Section included discussions on "Wegener's Hypothesis of Continental Drift," and on the "Geological History of the North Sea Basin" and a paper by Prof. A. P. Coleman on "Pleistocene and Recent Ice Conditions in north-eastern Labrador."

The Cosmical Physics sub-section of Section A joined the Geography section in a discussion on "Monsoons," and also joined the Economics and Agriculture Sections in one on "Weather Cycles in Relation to Agriculture and to Industrial Fluctuations."

The "Meteorological Luncheon" was again held, the seismologists joining the meteorologists as on previous occasions. The party, which numbered 30, assembled at Powolny's restaurant and included Sir Napier and Lady Shaw, the Rt. Hon. Lord Bledisloe (President Agriculture Section), Sir William Beveridge, Dr. G. C. Simpson, Col. H. G. Lyons and Mr. A. P. Lyons, Prof., Mrs. and Miss Turner, Prof. E. W. Brown, Dr. and Mrs. J. S. Owens, Mr. G. G. Chisholm, Mr. and Mrs. J. Downs and Mr. B. W. Downs, Dr. G. W. Grabham, Dr. H. Borns, Dr. Harold Jeffreys, Dr. C. W. B. Normand, Mr. J. J. Shaw, Mr. F. A. Bellamy, Miss E. F. Bellamy, Miss Winchester, Mr. J. E. Clark, Mr. W. G. Mitchell, Capt. W. H. Pick, Mr. M. A. Giblett and Mr. W. Andrews.

M. A. G.

Official Publications.

Geophysical Memoirs No. 19. Hurricanes and Tropical Revolving Storms. By Mrs. E. V. Newnham, M.Sc. With an Introduction on *The Birth and Death of Cyclones.* By Sir Napier Shaw, F.R.S. Pp. viii+122, illus. 1922. Price 12*s.* 6*d.*

THE preparation of this Memoir was the outcome of an inquiry from the Colonial Office as to the incidence of tropical storms in various parts of the world. The scattered literature of the subject has been analysed and arranged in a form convenient for reference. It is hoped that some account of the Memoir will be published later in this Magazine.

Correspondence.

To the Editors, *The Meteorological Magazine.*

The Design of Rain-gauges.

I HAVE read with interest the article on the design of rain-gauges in *The Meteorological Magazine* for July, 1921, and Mr. Halliwell's letter in the following number.

May I suggest that, at any rate in the tropics, item 3 of the "essential features" should be added to, and the existence of an inner collecting vessel of not more than half the diameter of the main gauge be recommended. This will involve in general two receivers, the outer one of which may, on occasion, be the whole body of the gauge, though this is undesirable if the capacity of the smaller one is often exceeded in a single day's rainfall.

The best way I can demonstrate this point is from the results of an experiment here in which I had six 5-inch gauges in a row, roughly north-west to south-east, seven feet apart, the dominant wind being south-west, and all the rims 12 inches above the ground. The gauges were alternately of the standard type, with receivers of diameter $4\frac{1}{2}$ inches, and of the British Association type, with no upper cylinder, and the rim immediately above the oblique face of the funnel, but having inner receivers with a diameter of 2·5 inches and a capacity of 2·3 inches of rainfall.

By the accepted criticisms of the British Association gauge they should have recorded less than the others on account of splash and wind eddies. The difficulty with snow does not arise here, but the intensity of tropical rainfall is proverbial, so that splash certainly had its opportunity. The experimental fact was that the British Association gauges with small receivers recorded more than the others, notably on days of little rainfall, when the odd hundredth or couple of hundredths might be 10 per cent. of the whole. On October the 30th, when there was over 2 inches of rain, the difference was less than 1 per cent.

The point of these experiments was not as between the Snowdon and British Association funnels, but in regard to the containers, and it is clear that either pattern of container can be put under either pattern of funnel.

As far as I can see, it was largely a matter of evaporation. I have found the under side of the funnels of the standard gauges covered with moisture in the morning of days when about ·05 in. of rain had fallen, while those of the British Association gauges were apparently dry. I do not believe that this difference was in any way a function of the funnels, but of the receivers; the little ones not only had a smaller water surface, but had a

free air-space between their outer surface and the inner surface of the main gauge. This would account for the agreement on the day of the heavier rain, when the tendency to evaporate was in any case so small that precautions against evaporation were unnecessary. It is probable that the point would be less appreciable in the British Isles, but as there are a good many parts of the Empire that get their meteorological supplies from London, a note may not be out of place.

I may add that in this particular case I do not think wind eddies came into play very much, as a previous experiment on the same site, lasting several years, showed that two British Association gauges, one of which was reinforced by a guard a couple of feet in diameter, showed very little difference (*i.e.*, the guard was superfluous), although a similar pair in another part of the grounds showed more rain in the shielded gauge.

On January 9th, 1922, in order to see how far the rims or the receivers were responsible for the difference in the readings, I exchanged four of the receivers—*i.e.*, the outer covers and rims were not changed, but the small receivers from under gauges Nos. 2 and 4 (British Association rims) were taken out and put under gauges 3 and 5 (standard rims) and conversely. As was anticipated, the effect of the change was to increase the amounts under the standard rims that now had small receivers, and to decrease the amount under the British Association rims that now had large receivers.

The percentage offsets from the reference gauge in each of the periods is shown in the Table below :—

Date and Type of Rain. 1″ per day as Criterion.	8″ Reference Gauge.		Percentage Offset of Experimental Gauges.					
			1 Standard Rim.	2 British Assn. Rim.	3 Standard Rim.	4 British Assn. Rim.	5 Standard Rim.	6 British Assn. Rim.
			Large receiver.	Small receiver.	Large receiver.	Small receiver.	Large receiver.	Small receiver.
	in.	mm.	%	%	%	%	%	%
19.9.21 to 9.1.22 Light	13·17	334·5	− 6·8	− 0·4	− 7·2	− 1·1	− 3·7	+ 0·4
9.1.22 Heavy	4·48	113·8	− 0·9	+ 0·4	− 1·3	− 0·4	− 0·4	0·0
			Large receiver	Large receiver	Small receiver	Large receiver	Small receiver	Small receiver
10.1.22 to 13.6.22 Light	14·85	377·1	− 5·6	− 5·8	− 3·4	− 4·9	− 1·6	− 3·5
13.6.22 Heavy	22·28	565·9	− 0·9	− 0·8	0·0	− 0·5	− 0·5	− 0·2

On comparing the effect of the changes, the following results were obtained :—

Gauges.	Change in Receiver.	Mean change in offset percentage.	
		Heavy Rain.	Light Rain.
1 and 6	No change	− 0·1	− 1·3
2 and 4	Small to large	− 0·6	− 4·6
3 and 5	Large to small	+ 0·6	+ 2·9

The change of −1·3 found in the case of the unaltered gauges 1 and 6 must be attributed to errors in observing, to the effect of difference of site (which might be noticeable in the north-east or south-west monsoon), or to difference in humidity, and hence in evaporation. The agreement in the case of the heavy rainfall suggests that the effect is not wholly one of poor observation; it must be largely due, therefore, to a seasonal change in wind and humidity. So that, in order to estimate the changes due to difference in receivers, the values must be corrected for this seasonal variation. For example, in the case of light rain, the offsets −4·6 and + 2·9 can be regarded as (− 3·7 − 0·9) and (+ 3·8 − 0·9), where 0·9 is the common seasonal difference comparable to the 1·3 change in the outside gauges 1 and 6.

A further experiment on evaporation was tried on August 9th and 10th. It was purely an artificial test, as the day was rainless and so more conducive to evaporation than a rainy day. At about 9 a.m. on the 9th the six gauges, arranged as before, were filled with water so that in each case the tip of the pipe was below the water-level. It will be seen that water vapour from the bulk of the evaporating surface is prevented from escaping, except through any passage which might have been left between the lower parts of the funnels and the upper parts of the containers. The standard rims fit more closely than the British Association rims. A very small quantity of vapour will escape, also, from the area enclosed by the pipe.

The table below shows the results of the experiment :—

Gauge.	Rim.	Receiver.	Water put in on Aug. 9th.	Water measured on Aug. 10th	Loss.	State of inside of gauge on the morning of August 10th.
			in.	in.	in.	
1	Standard	Large	4·69	4·64	·05	Under side of funnel and vertical walls very wet. Large drops on base outside receiver, which had evidently run down the walls.

Gauge.	Rim.	Receiver.	Water put in on Aug. 9th.	Water measured on Aug. 10th.	Loss.	State of inside of gauge on the morning of August 10th.
2	Brit. Assn.	Large	2·84	2·81	·03	A few drops under funnel, but nothing appreciable on base.
3	Standard	Small	1·95	1·93	·02	Drops on vertical underside of funnel and vertical walls, but not on base.
4	Brit. Assn.	Large	2·91	2·86	·05	Drops on under side of funnel and walls; more than on No. 3, but less than on No. 1.
5	Standard	Small	1·95	1·93	·015	Similar to No. 3.
6	Brit. Assn.	Small	1·38	1·37	·015	No moisture detected on inner surface of funnel or walls.

The large receivers lost in all ·13 in., and the small receivers only 0·5 in. A certain amount of water vapour escaped at the joint; for example, No. 6 lost a little with nothing to show for it in condensed form and the appreciable amount of recondensed water in No. 1 does not explain the total loss of ·05 in. With similar receivers the loss under standard rims is slightly greater than under British Association rims.

The experiment shows, therefore, that (1) loss by evaporation is a function of the receiver; (2) in both types of gauge some water-vapour escapes at the joint; and (3) standard gauges admit of more loss by evaporation than can be compensated for by the more accurate fit of the rim. A. J. BAMFORD.

Colombo Observatory, Ceylon, August, 1922.

[Mr. Bamford rightly lays stress on the fact that the results he has obtained depend not upon the type of funnel but upon the container. We have often pointed out that the funnel defects of the British Association gauge are relatively unimportant if the position of the gauge is sufficiently sheltered from wind eddies, although the risk of outsplash is always present. The small container usually provided with the British Association gauge is probably a mere accident, but it is an accident which happens to give the degree of thermal insulation so necessary in tropical climates. It is, however, a very clumsy method of achieving the immunity from evaporation which Mr. Bamford points out is desirable. An important point is the facility for sinking the lower part of the body of the gauge in the ground, a course which is practically impossible with the short British Association pattern. Evaporation can be practically completely prevented if a glass bottle be placed within the metal receiver

to contain the collected water. A further precaution would be the adoption of Casella's insulated rain-gauge (see *Symons's Met. Mag.*, Vol. 45, 1910, p. 182), a pattern admirably suitable for tropical conditions.—Ed. *M.M.*]

Shortage in Shallow-funnel Rain-gauge compared with Snowdon Gauge.

FROM 1906 to 1920 I kept records of rainfall in two types of rain-gauge standing side by side at Asgarth, Purley, at 360 feet above mean sea level on a north-east slope and fully exposed. The results were as follows:—

	Snowdon gauge.	Shallow-funnel gauge.	Percentage Difference.
	in.	in.	
Mean, 15 years -	31·48	31·16	1·0
Most in 1916 - -	39·58	39·15	1·1
Least in 1907 -	25·30	25·10	0·8
Least diffce., 1906 -	30·43	30·37	0·2
Most diffce., 1918 - -	33·66	33·12	1·6
Also, 1919 -	29·29	28·78	1·7

The last gives the highest percentage difference of 1·7 per cent., the mean difference being exactly 1 per cent.

As the station is of fair average character for an open and rather exposed situation these values may be of interest. Snow records were estimated as the same for both.

J. EDMUND CLARK.

41, *Downs Court Road, Purley, Surrey, September 3rd*, 1922.

Seasonal Variation of East Wind.

MR. BAXENDELL'S information on the monthly frequency of easterly winds at Southport entirely corroborates a table I had already prepared for London using the geostrophic wind-data published in this Magazine during 1920. Comprising under the designation "east" directions from east, north-east and south-east, or leaving out south-east, since not only is the frequency of this direction small but the seasonal variation is also small, I find a very pronounced and protracted season in spring, and a much less conspicuous, shorter season in autumn.

The primary spring maximum of cases of north-east and east winds is prominently embraced by the four months, March, April, May and June, and the secondary autumnal maximum is in September, October and November. As Southport is in the north-west of England, and London in the south-east, this is doubtless typical of the country as a whole.

It appears, therefore, that the proverbial east wind of spring which figures so much in our experience and literature, prevails as regards actual frequency of occurrence in the true spring or equinoctial period, March and April, and in the earlier half of the summer period May and June; but speaking climatologically, it would, perhaps, be truer to say that the real season is limited to March and April, inasmuch as the easterly winds of May and June are much milder both in temperature and strength. Indeed, if the easterly current happens to be reaching us straight from the unheated Continent it commonly brings warm thundery weather as early as May. Similarly, on the autumnal side of the year, my figures show a higher frequency in September than in November, but the November tendency is more noticeable in common experience because by then the east wind has acquired the sting of winter.

L. C. W. BONACINA.

Hygrometry.

I WAS more than usually interested in the first article of the May issue of *The Meteorological Magazine*. With regard to the use of the dry and wet bulb thermometers for hygrometric purposes, for many years past it has seemed to me that a better plan (for the traveller, at any rate) is to use one thermometer only, and make it report on itself, wet to dry. A good instrument well adapted to be "slung" is readily obtainable; and a wet cap for the bulb can be made sufficiently dense to retain its wetness (not mere dampness) during the few minutes involved.

This last week I have been experimenting with such a device, and comparing results with a "Mason's Hygrometer" in the garden; and I have repeated the operation indoors. As the outdoor instrument is well ventilated, agreement there is quite satisfactory; but indoors the "slung" wet bulb will run two or three degrees lower in temperature than the stationary one. This is in good agreement with the article referred to.

In framing his tables to be used with the wet and dry bulb thermometer, Glaisher seems to have used to some extent Daniell's form of hygrometer. I have employed such a one on occasion for many years past, and often found its behaviour satisfactory. But there were (and are) times when the sought dew-point being very low, atmospheric vapour would attack the muslin of the condensing bulb, and so slow down the action of the sulphuric ether that no result could be got so far as the observation bulb is concerned. In cold weather this defect frequently leads to a display of hoar frost on the muslin. Other observers must be familiar with this defect, but I cannot remember having seen it noted. WILLIAM GODDEN.

20, *Richmond Avenue, Willesden, N.W.* 10, *June* 10*th*, 1922.

The Green Flash—An Unusual Feature.

ON September 20th I observed the "green flash" at sunset from my house at Wadhurst, Sussex, and noted a feature which I have not seen described in previous accounts of the phenomenon.

The sun set over low hills in the Ashdown Forest region and at a distance estimated at eight miles from the point of observation and several isolated rounded trees were projected on the disc for some time before the sun's disappearance. The largest of these trees subtended an angle estimated at about two minutes of arc. The observation was made with a telescope of three inches aperture magnifying eighteen diameters.

The phenomenon occurred in two stages: (*a*) Every tree projected on the disc became suddenly outlined with a narrow hazy border of green light, the rest of the sun retaining its normal colour; (*b*) after a perceptible interval of time the whole of the remaining segment of the sun turned a brilliant clear emerald green and almost simultaneously disappeared below the horizon.

The sky was entirely clear at the time, with a little haze at low altitudes, so that while the setting sun was a golden colour only slightly tinged with red, the light was sufficiently reduced to enable it to be viewed directly without any dazzling or retinal fatigue effects.

E. W. BARLOW.

Oct. 5th, 1922.

A Red Rainbow.

AT 19h. 40m. on Sunday, July 30th, 1922, from the Western Esplanade, Hove, I observed over the sea about 20° of the southern end of a very remarkable rainbow—a pillar of a dark red brick colour, the red so intense that none of the other prismatic colours could be detected. The western sky at this time was gorgeous in brilliant yellow gold, the sun itself being hidden by a cloud-bank. Gradually the red pillar stretched up and curved over until by 19h. 47m. it reached to a point above the South Downs and about 150° from the sea. The intense redness of the bow was maintained, and continued to swamp other colours, except for a faint indication of green in one or two short spaces immediately above the sea, near which was a faint secondary of about 15°, the same red colour only. Sunset was at 19h. 51m., but the bow, fading away from the northern end, did not vanish until 19h. 56m. The clouds overhead then assumed a soft rose tint, and the sky to west and north-west became a brilliant red. The automatic gauge in the Old Steine, Brighton, registered rain from 19h. to 23h., total ·15 in.; the ordinary gauge, ·11 in.

In my long life I have seen many rainbows, but never before have I beheld a red one—it even imparted a tinge of its redness to the atmosphere! A singular feature deserving of special mention was the appreciably greater breadth of the bow in the section above Brighton, a fact which attracted the attention of others as well as myself. H. HARRIES.

July 31st, 1922.

Note added October 4th.—A fortnight later than the above, 15 min. before to 5 min. past sundown, another, but much less complete, bow of the same redness was observed from the King's Esplanade.—H. H.

A Halo in False Cirrus: Interlacing Air-currents.

A SEMI-CIRCUMFERENCE of an exceptionally brilliant halo was in evidence here to-day from 13h. to 13h. 10m. G.M.T.

The sky was practically overcast with low fracto-nimbus (or scud) and strato-cumulus immediately above. Through the gaps could be seen flotillas of alto-cumulus with a thin veil of false cirrus between the strato-cumulus and alto-cumulus. Away to the north showed massive tops of cumulo-nimbus.

The sun gleamed through at about 13h. and an extremely brilliant semicircle could be seen. The outer edge showed gleaming white, changing somewhat abruptly to the dull red-brown of the inside. Measurements hastily made gave a radius of approximately 2°, allowing for the errors due to difficulty in aligning theodolite sights at such a high elevation.

An accompanying point of interest is that the low fracto-nimbus was moving rapidly from south-east, while the strato-cumulus, but very little higher, was drifting more slowly, but quite definitely from north-west by north. The movements were ascertained by nephoscope observation.

The surface wind, during the morning about 10 miles per hour from west-north-west, backed suddenly at 11h. 50m. to south, with little change in velocity.

Rain showers had fallen frequently since 10h.

Aberdeen, August 3rd, 1922. P. F. JARROLD.

[The following information in amplification of Mr. Jarrold's letter has been obtained :—

The striking difference of wind-direction between the surface and the strato-cumulus level persisted for at least three hours. Between 13h. and 15h. the direction from which the low cloud was moving slowly changed to south, whilst that of the strato-cumulus changed to west.

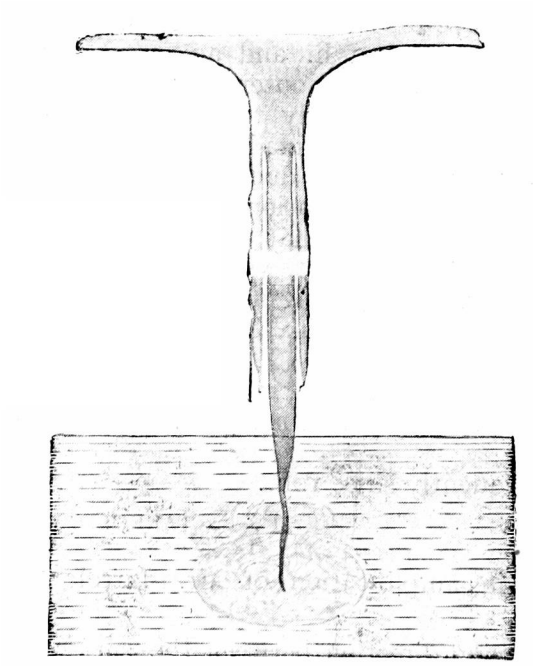
The anemogram from Dyce (6 miles to the north-east of Aberdeen) shows that the light north-westerly wind persisted there until 14h, when it was suddenly displaced by a more vigorous current from the east. On the other hand at 16h. 45m. simultaneous shifts of the wind through a right angle occurred, from south to east at Aberdeen, from south-east to north-east at Dyce.

At Aberdeen the south-easterly current was about the same temperature as the north-westerly one, but considerably damper, with humidity 90 per cent. in place of 80 per cent.—ED. *M.M.*]

NOTES AND QUERIES.

Some Observations of Waterspouts and Allied Phenomena.

A Waterspout with a "Sheath."



DR. G. D. Hale Carpenter contributes to *Nature* of September 23rd an interesting account of a waterspout observed on June 30th from the north shore of Bugalla, the largest island in the Sese Archipelago, Victoria Nyanza. The illustration, which is reproduced from *Nature*, shows the unusual structure of the waterspout.

Dr. Carpenter writes: "Surrounding the central core, but separated from it by a clear narrow space, was a sheath, the lower end of which faded away some distance above the water. The profile of this sheath was undulating, it being thicker in some places than others. A curious point is that this sheath seemed to pulsate rhythmically, but I could not say whether the appearance of pulsation

might not have been an illusion caused by waves travelling up its outer surface.

" This pulsation gave an uncanny suggestion of a live thing, which was aided by the violent spiral movement upwards in the central core, the clouds of vapour boiling round its base, and the movement of the whole across the water—indeed, we watched it spell-bound until the pedicle dissolved away at the bottom, and the ascent of the part above brought the phenomenon to an end . . . I cannot estimate the height to which the column rose. Its cessation was followed by violent rain and thunder."

Two Cloud Pendants.

A description of two cloud pendants is contributed by Major W. C. Ball, D.Sc., F.I.C. They were observed by him from Clovelly Harbour at about 10 a.m. on September 1st, 1922.

Both pendants were in the form of inverted cones, which depended from the well-defined and dense black under-surface of a cloud. In the case of one pendant, the cone continued in the form of a long tail similar to the lash of a whip. This tail extended about two-thirds of the way down to the sea and was bent into a curve, so that at its lower end it was almost horizontal. The edges of the tail were quite sharp and well-defined. Major Ball thinks that the tail pointed approximately into the direction *towards* which the wind was blowing. Below the lower end of the tail another portion was seen rising from the sea. " The part rising from the water was less distinct than the tail, which was very sharply defined; it appeared later and had a curious filmy appearance. I don't think it was directly below the end of the tail, but I am not certain. I judged that the spout might be about two miles from the shore, and that the part rising from the water was certainly higher than the mast of a fishing boat."

The phenomenon remained visible for about ten minutes and was lost to sight by being carried behind the headland towards Bideford.

Major Ball describes the weather at the time as squally with showers, and the wind as light or moderate.

Captain D. Brunt's remark on waterspouts, written in amplification of Dr. Hale Carpenter's letter and published in the same issue of *Nature* is *à propos*:—

" The thickness of the visible column or zone of condensation therefore diminishes downward, giving the form of an inverted cone of irregular shape. Near the water the air is again near saturation, and the difference between air temperature and dew-point is small, so that the base of the whirl is widened.

It frequently happens that the portion at middle heights is not visible, on account of the relative dryness of the air."

A Waterspout with Fireballs.

The Times of September 5th, 1922, contains a letter from the Reverend G. D'Arcy Blackman, of Wymondham, Norfolk, in which he describes a curious waterspout and asks for some explanation of the phenomenon. He writes :—" A small waterspout was noticed over Norfolk on Friday evening (September 1st) at 6.30 p.m., which, as far as I understand the phenomena, was remarkable by not ending in a heavy downpour of rain, but by releasing two small fire-balls. At any rate, two small fiery substances fell to the ground . . . The waterspout ended in taking the shape of a foot and then gradually dissolved. Most of the village folk—some of seventy years of age—said that the sight was something that they had never seen or heard of."

A Curious Cloud-Pendant.

A curious cloud-pendant was observed by Mr. H. W. Clarke at Killowen at mid-day on August 11th, 1922. The outlines of the pendant were remarkably distinct, the edges appearing as straight as if ruled. The pendant was bent sharply near its extremity, seeming to disappear behind the Knockshee Mountains, towards which the observer was looking. The diameter of the pendant is described as about half the apparent diameter of the sun. The phenomenon was witnessed by many people.

The Audibility of Explosions.

THE International Commission for the Investigation of the Upper Air appointed in 1921 a sub-commission to investigate the transmission of sound of an explosion. Various war ministries were asked to collaborate in the research by arranging for experimental explosions. The Dutch Ministry of War agreed to explode a large quantity of ammonia at Oldebrack on the first day after September 23rd suitable as regarded meteorological conditions. The Air Ministry issued a notice to the press asking for observations of the sound and giving instructions for such observations, which were to be forwarded to the Director of the Meteorological Office. Subsequently, however, it has been reported that people living near Oldebrack have objected to the scheme on the ground that it might cause damage in the town.

It is to be hoped that some way out of the difficulty will be found. Perhaps the best place for a great explosion would be

the middle of the North Sea. It should be emphasised that the principal requirement on the meteorological side is a complete set of upper air observations, giving air temperature and wind velocity over a large area. Clear skies are to be desired so that observations of pilot balloons up to great heights may be secured. Under such conditions reliable computations of the trajectories of the sound waves should be possible.

Exceptional Visibility as a Sign of Coming Rain.

IN view of the widely-held belief that exceptional visibility is a sign of coming rain, the observations taken at the Meteorological Office, Cranwell, during the 518 days from April 1st, 1920, to August 31st, 1921, have been examined by Mr. W. H. Pick.

Visibility is observed hourly at Cranwell; in the following classification a day with "visibility of 21 miles or more" is a day on which such visibility was observed at one or more of the hours from 9 h. to 17 h., and similarly with a visibility of 13 miles. The days with "visibility of 13 miles or more" include also those with 21 miles or more. "Rain before 7 h." refers to appreciable rain (0·2 mm. or more) during the period between the observation of visibility and 7 h. on the following morning.

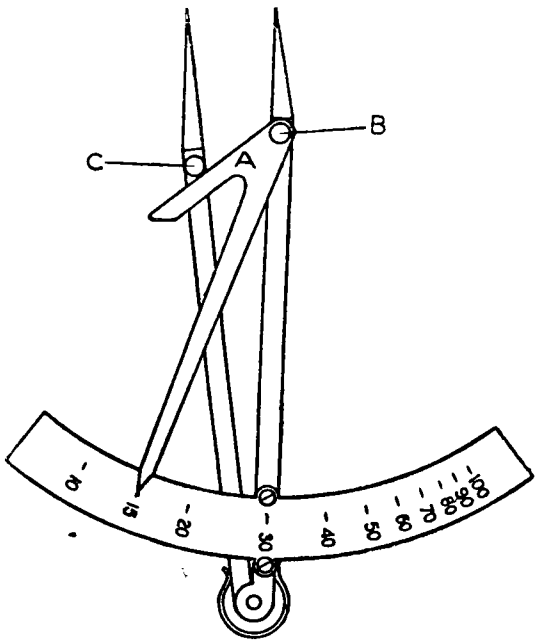
	Days with visibility of 21 miles or more.	Days with visibility of 13 miles or more.	Other Days.	All Days.
Total Days	43	216	302	518
Days with rain before 7 h.	14	83	150	233
Percentage -	33	38	50	45

It will be seen from the table that, so far as Cranwell is concerned, there is no evidence that a day of exceptional visibility is more likely to be followed by rain than a day of low visibility, but rather the reverse. Only one-third of the days on which visibility reached 2 miles were followed by rain; while, in the case of days on which visibility did not reach 13 miles, the proportion is one-half. It should be noted, however, that during a large part of the period examined the conditions were abnormal, both as regards rainfall and clearness of the atmosphere.

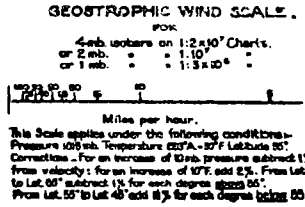
Geostrophic Dividers.

THE instrument shown in the accompanying illustration was designed and made at Benson Observatory by Mr. H. W. Baker, for determining the velocity of the geostrophic wind* directly from a synoptic chart.

The velocity in question is determined by the well-known formula $\gamma = 2\omega v\rho \sin \phi$, where γ is the pressure gradient, ω the angular rotation of the earth, v the geostrophic velocity, ρ the density of the air, and ϕ the latitude.



Hitherto the velocities have been determined by the use of a scale such as is illustrated below. Such a scale can be made for any chart by using the formula quoted, the actual scale lengths being determined by the size of the chart used.


GEOSTROPHIC WIND SCALE.
FOR
4-mb. isobars on 1:2·5×10⁷ Charts.
or 2 mb. " " 1:10⁷ "
or 1 mb. " " 1:5×10⁶ "
Miles per hour.
This Scale applies under the following conditions:-
Pressure 1013 mb. Temperature 60°A.=57°F. Latitude 55°.
Corrections.-For an increase of 10 mb. pressure subtract 1%
from velocity: for an increase of 10°F. add 2%. From Lat. 89°
to Lat. 66° subtract 1% for each degree above 66°.
From Lat. 55° to Lat. 45° add 1½% for each degree below 55°.

The tables printed in *The Computer's Handbook*, Section 2, pp. 71–74, which give distances apart in nautical miles of con-

* **A short explanation of the significance of the geostrophic wind is given in this Magazine, February, 1920, p. 8.**

secutive 10 millibar isobars corresponding with various geostrophic velocities, are based on this formula and are capable of adjustment to any sized map.

It will be seen that in this scale the graduations corresponding with strong winds are inevitably crowded together, so that interpolations are impracticable. Mr. Baker's aim has been to get a much more uniform graduation.

His instrument consists of a pair of legs hinged together; attached to one of the legs is a straight-edged cam (A), which can turn on the bearings (B) and make a sliding contact with the stud (C) on the other leg. Pressure on the stud is maintained by a spring. Fixed to the cam is an arm which serves as an indicator and as a lever for adjusting the divider-points on the isobars. When set, this lever retains its position on the scale by friction.

The scale is graduated from 10 to 100 miles per hour by divisions corresponding to each 10, and, although the graduation is not uniform, velocities may easily be read to within a mile or two per hour* on any part of the scale.

With the exception of the scale the instrument is made throughout of steel, all bearings and sliding surfaces being hardened to prevent wear.

The particular instrument illustrated was designed for use in latitude 55° with 4 mb. isobars on a chart to the scale $1 : 2 \times 10^7$, at a pressure of 1,015 mb. and temperature 50° F.

Meteorological Office Standard Wind-Vane.

IN *The Meteorological Magazine* for April, 1921, a description was given of a new type of vane which is now used for pressure tube anemometers with direction recorders. In this type the fin of the vane is a considerable distance from the axis, so that a counterweight of an appreciable size has to be fitted to the forward end near the opening of the pressure pipe in order to ensure that the vane is balanced about its pivot.

It having been suspected that this counterweight might produce an effect upon the air pressure in the pressure pipe itself, arrangements were made with the National Physical Laboratory for a test of one of the vanes in a wind channel. The Laboratory reports that, on comparison with their standard total-pressure tube, the new type of vane was found to give readings correct within limits of ½ per cent. It thus appears that the presence of the counter-weight has no appreciable effect.

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* It is not to be supposed, however, that this order of accuracy has any physical significance.—ED. *M.M.*

Radiation from the Sky.

RADIATION MEASURED AT BENSON, OXON, 1922.

Unit 1 one gramme calorie per square centimetre per day.

ATMOSPHERIC RADIATION only (dark heat rays).

Averages for Readings about time of Sunset.

		July.	August.	Sept.
Cloudless days :—				
Number of readings	n	6	6	8
Radiation from sky in zenith	πI	541	517	509
Total radiation from sky	J	576	544	554
Total radiation from horizontal black surface on earth.	X	756	720	750
Net radiation from earth	X–J	180	176	196

DIFFUSE SOLAR RADIATION (luminous rays).

Averages for Readings between 9 h. and 15 h. G.M.T.

Cloudless days :—				
Number of readings	n_0	0	2	4
Radiation from sky in zenith	πI_0	?	28	28
Total radiation from sky	J_0	?	31	48
Cloudy days :—				
Number of readings	n_1	5	5	4
Radiation from sky in zenith	πI_1	155	145	152
Total radiation from sky	J_1	125	116	131

Unit for I = gramme calorie per day per steradian per square centimetre.

Unit for J and X = gramme calorie per day per square centimetre.

For description of instrument and methods of observation, see *The Meteorological Magazine*, October, 1920, and May, 1921.

Meteorology and Civil Aviation in India.

THE *Half-Yearly Report on Civil Aviation in India* for January to June, 1922, contains, in addition to flying news, a table of cloud and upper-air observations on the Calcutta-Rangoon route during the month of June. Heavy monsoon weather prevailed over this district; but, in spite of this fact, flying was possible on most days. It is interesting to notice that, in connection with civil aviation, upper-air observations are being carried out systematically in various parts of the country.

The Sound of Aurora.

THE observer at Deerness, in the Orkneys, reports: "On the evening of the 20th and morning of the 21st [of September, 1922] there was the kind of aurora which spreads in clouds of light, and when very brilliant may be heard to give a little sound like the sound made when sifting meal in skin sieves. I have only heard the sound three or four times."

The sound of aurora is a subject open to much discussion, since some travellers in high latitudes record noises of varying intensity, from the "rustling of silk" to the sound of a "squall of wind in the upper rigging of a ship"; while others report that, though the aurora appeared very near, no sound was to be heard. It is certainly an unusual phenomenon.

Obituary.

VICTOR HERBERT GATTY.—Mr. V. H. Gatty, whose death from heart failure whilst shooting on the moors occurred on August 12th, was an enthusiastic amateur meteorologist, and had been for many years a rainfall observer and occasional contributor to this and other scientific journals. We have received the following personal appreciation from his friend, the Rev. R. P. Dansey:—

"It was a fortunate inspiration which induced the writer to pen an article descriptive of the Glacial Snow of Ben Nevis for this Magazine (Vol. 40, March, 1905). When inspecting the snow beds in July, 1905, I met Mr. Gatty doing the same thing, having seen the article in question. Thus started a warm friendship of seventeen years. Mr. Gatty was keenly interested in British snow-beds and moraines, and in the *Geographical Journal*, Vol. XXVII., May, 1906, there appeared under his name an illustrated article entitled 'The Glacial Aspect of Ben Nevis.' He was a fellow of the Royal Geographical Society and a member of the Alpine, and Fell and Rock Climbing Clubs. He loved the peaceful solitude of the hills and as his guest I climbed with him in the Tyrol, the Graian Alps, the Pyrenees, Norway and Corsica. Two of these expeditions provided material for articles on the Pyrenees and Corsica in these pages, while an article on 'A Long Day on the Justedalsbræ' in Norway appeared under his name in No. 3, Vol. 2, of the *Fell and Rock Climbing Club Journal*. Never a robust man, his varied activities during the war caused overstrain, and he was never equal to serious walking or climbing afterwards. He once expressed a wish to die on a glacier, when his time should come; but, failing this, he could hardly have wished anything better than to pass away amid the peaceful heather-covered solitudes of a Scottish grouse-moor.—R. P. DANSEY."

News in Brief.

In view of the present interest in " gliding " or " air sailing," the *Daily Mail* has announced a Gliding Competition for a prize of £1,000. The contest, which is to be conducted by the Royal Aero Club, will take place on October 16th to 21st. Should gliding become a popular sport, it promises to yield developments of importance in technical aeronautics, and as its successful practice depends on a knowledge of vertical air currents, stimulus should be given to meteorological research, more especially on the physical structure of the lower atmosphere.

The observer at Ross-on-Wye reports that, at 17 h. on September 6th a dense overhead fog of a greenish tint overshadowed the town, causing such intense gloom that artificial light was necessary. A little rain fell towards 17 h. 30 m., and continued until after 18 h., but the shower was quite local. Outside the town no rain occurred.

Erratum.

September, 1922, page 214, paragraph 5, line 4, *for* " Ireland " *read* " Iceland."

The Weather of September, 1922.

THE widespread belief that a fine September follows a bad summer has found little justification in 1922. A fair week beginning on the 3rd and a few days about the 23rd were the only settled periods during the month. Mostly the month was unsettled, wet and cold. Rainfall was not generally in excess of the average, but sunshine amounted in most places only to about two-thirds of the average.

On the 1st a low pressure area with several centres extended from Spitzbergen over the British Isles to the Bay of Biscay, while there were anticyclones over Scandinavia and the Azores. Unsettled weather resulted generally, except in Scandinavia, with heavy rain and thunder locally. A thunderstorm at Blackpool on the 2nd gave 78 mm. of rain and caused considerable damage. On the 3rd and 4th the Scandinavian anticyclone extended in a south-westerly direction, with generally quiet but dull weather. A large anticyclonic system was thus established, extending from the Azores to Scandinavia, which persisted for several days, giving a period of quiet weather with night fogs and fairly warm days. By the 8th pressure at the Scandinavian end of the " ridge " had decreased, but at the Azores end it had increased and the area affected had extended north to include Iceland. This northward extension began to recede on the 9th before a depression to the north of Iceland which caused gales and rain, and by the morning of the 11th the anticyclone

THAMES VALLEY RAINFALL ——SEPTEMBER, 1922.

H.M. Stationery Office Press, Kingsway, W.C.2.

P.S. 1579/6/6. Mt. 68. D. R. 1000. 10/22.

was established in its more usual position over the Azores, with the whole of Scotland under the influence of the Icelandic depression.

On the 12th, a depression, off the Hebrides in the morning, moved south-eastwards over the British Isles, causing general rainfall and gales in the Channel. Acquiring a northerly component on the 13th this depression moved slowly across the North Sea on the 13th, 14th and 15th with strong cold northerly winds and cloudy showery weather, with local thunder behind it. Some of the higher peaks in Scotland received a light dusting of snow on these days.

The appearance of another depression off the Hebrides on the morning of the 16th brought three distinct cyclonic systems into our area, the one which had crossed England being over the Baltic and a third within the Arctic Circle south of Spitzbergen. In all northern areas rainy weather resulted, but southern England and Central Europe enjoyed a fair day. The eastward movement of this complex system on the 17th and 18th brought a showery type of weather to the British Isles and gales in Scandinavia. A depression north of Scotland moving rapidly to the east gave much rain and wind on Tuesday the 19th and improving colder weather on the Wednesday. A "high" following this gave a few days of generally pleasant settled weather.

On the morning of the 25th a very deep depression was situated off the west of Ireland. At 7h. G.M.T. the *Aquitania*, near the centre of the depression, reported a pressure of 952 mb. (28·11 in.); at 13h. the same day she reported a wind of hurricane strength (force 12; Beaufort scale). Fortunately this depression filled up as it drifted slowly eastwards; it finally disappeared over France on the 28th. Although gales were caused on parts of the coast, they were not of excessive violence.

R. A. W.

A message from Rome dated the 8th stated that the Apulian city of Lecce had been swept by a violent storm, which unroofed 600 houses and seriously damaged many churches. On the early morning of the 28th the fort on Monte Falconara, about 8 miles from Spezia (Liguria), was blown up during a heavy thunderstorm. As the fort contained 1,500 tons of explosives, widespread destruction resulted. The adjacent village of San Terenzio was almost entirely destroyed, with considerable loss of life, and the effects of the explosion were felt as far as Spezia.

It was reported from Ponta Delgada on the 4th that the *Quest*, which arrived on that date, had been driven west and delayed by strong north-westerly winds in the North Atlantic. The month was noteworthy for violent storms in this ocean.

(*Continued on p.* 262.)

Rainfall Table for September 1922.

STATION.	COUNTY.	Aver. 1881–1915.	1922.		Per cent. of Av.	Max. in 24 hrs.		No. of Rain Days.
		in.	in.	mm.		in.	Date.	
Camden Square	*London*	1·82	2·13	54	117	·39	14	14
Tenterden (View Tower)	*Kent*	2·14	2·93	74	137	·53	23	15
Arundel (Patching Farm)	*Sussex*	2·40	2·10	53	88	·65	12	13
Fordingbridge (Oaklands)	*Hampshire*	2·15	1·72	44	80	·72	12	17
Oxford (Magdalen College)	*Oxfordshire*	1·68	1·26	32	75	·28	14	12
Wellingborough (Swanspool)	*Northampton*	1·80	2·09	53	116	·56	14	11
Hawkedon Rectory	*Suffolk*	1·93	3·12	79	162	·80	30	16
Norwich (Eaton)	*Norfolk*	2·14	2·62	67	122	·63	14	17
Launceston (Polapit Tamar)	*Devon*	2·80	3·88	99	139	1·81	12	15
Sidmouth (Sidmount)	„	2·30	2·55	65	111	·66	12	12
Ross (County Observatory)	*Herefordshire*	2·02	1·68	43	83	·44	12	14
Church Stretton (Wolstaston)	*Shropshire*	2·03	2·13	54	105	·45	12	15
Boston (Black Sluice)	*Lincoln*	1·76	2·32	59	132	·73	14	13
Worksop (Hodsock Priory)	*Nottingham*	1·52	2·32	59	153	·62	27	13
Mickleover (Clyde House)	*Derbyshire*	1·79	1·80	46	100	·34	27	13
Southport (Hesketh Park)	*Lancashire*	2·75	2·92	74	106	·62	12	16
Wetherby (Ribston Hall)	*York, W. R.*	1·80	3·02	77	168	·60	13	9
Hull (Pearson Park)	„ *E. R.*	1·72	2·08	53	121	·71	14	17
Newcastle (Town Moor)	*North'land*	2·04	4·34	110	213	1·00	13	21
Borrowdale (Seathwaite)	*Cumberland*	9·92	9·00	229	91	..	..	..
Cardiff (Ely Pumping Stn.)	*Glamorgan*	3·10	3·83	97	124	1·05	12	16
Haverfordwest (Gram. Sch.)	*Pembroke*	3·55	6·03	153	170	1·37	12	16
Aberystwyth (Gogerddan)	*Cardigan*	3·64	5·07	129	139	1·87	18	7
Llandudno	*Carnarvon*	2·28	2·10	53	92	·38	18	16
Dumfries (Cargen)	*Kirkcudbrt.*	2·94	2·90	74	99	·60	12	20
Marchmont House	*Berwick*	2·41	3·41	87	141	·58	28	17
Girvan (Pinmore)	*Ayr*	3·83	2·62	67	68	·45	12	22
Glasgow (Queen's Park)	*Renfrew*	2·77	1·58	40	57	·22	16	19
Islay (Eallabus)	*Argyll*	4·18	3·72	95	89	·97	16	22
Mull (Quinish)	„	4·79	3·38	86	71	·71	16	19
Loch Dhu	*Perth*	5·73	4·30	109	75	1·15	12	13
Dundee (Eastern Necropolis)	*Forfar*	2·08	2·33	59	112	·53	26	19
Braemar (Bank)	*Aberdeen*	2·51	1·95	49	78	·74	26	10
Aberdeen (Cranford)	„	2·34	3·47	88	148	1·25	26	19
Gordon Castle	*Moray*	3·50	2·60	66	104	·77	28	16
Fort William (Atholl Bank)	*Inverness*	6·32	3·54	90	56	·96	16	22
Alness (Ardross Castle)	*Ross*	2·92	1·98	50	68	·25	26,30	15
Loch Torridon (Bendamph)	„	6·95	3·84	97	55	·76	16	20
Stornoway	„	3·95	2·76	70	70	·58	16	22
Loch More (Achfary)	*Sutherland*	5·75	4·81	122	84	1·05	16	21
Wick	*Caithness*	2·50	2·81	71	112	·94	28	19
Glanmire (Lota Lodge)	*Cork*	2·80	3·83	97	137	1·07	26	15
Killarney (District Asylum)	*Kerry*	3·58	..	..	..	..	..	..
Waterford (Brook Lodge)	*Waterford*	2·77	2·53	64	91	·46	26	16
Nenagh (Castle Lough)	*Tipperary*	2·81	3·42	87	122	1·43	18	21
Foynes	*Limerick*	2·79	3·91	99	140	1·37	18	21
Gorey (Courtown House)	*Wexford*	2·47	3·11	79	126	·90	18	11
Abbey Leix (Blandsfort)	*Queen's Co.*	2·72	3·42	87	126	1·05	18	17
Dublin (FitzWilliam Square)	*Dublin*	1·92	2·58	65	134	·46	18	18
Mullingar (Belvedere)	*Westmeath*	2·67	2·61	66	98	1·13	18	14
Crossmolina (Enniscoe)	*Mayo*	3·92	..	..	..	..	..	..
Collooney (Markree Obsy.)	*Sligo*	3·35	3·97	101	119	·72	18	23
Seaforde	*Down*	2·75	3·05	77	111	·61	26	16
Ballymena (Harryville)	*Antrim*	3·11	3·28	83	105	·63	20	22
Omagh (Edenfel)	*Tyrone*	3·05	3·80	97	125	·85	20	20
Letterkenny Asylum	*Donegal*	3·40	2·99	76	88	·53	20	20

Supplementary Rainfall, September 1922.

Div.	STATION.	RAIN. in.	RAIN. mm.	Div.	STATION.	RAIN. in.	RAIN. mm.
II.	Ramsgate	3·71	94	XII.	Langholm, Drove Rd.	2·95	75
„	Sevenoaks, Speldhurst	2·51	64	XIII.	Ettrick Manse	2·71	69
„	Hailsham Vicarage	3·97	101	„	North Berwick Res.	2·18	55
„	Totland Bay, Aston Ho.	1·29	33	„	Edinburgh, Royal Ob.	1·72	44
„	Ashley, Old Manor Ho.	1·75	44	XIV.	Biggar	1·78	45
„	Grayshott	1·77	45	„	Leadhills	3·84	97
„	Ufton Nervet	1·67	42	„	Kilmarnock, Agric.Coll.	1·87	47
III.	Harrow Weald, Hill Ho.	2·17	55	XV.	Dougarie Lodge	3·04	77
„	Pitsford, Sedgebrook	1·85	47	„	Oban	2·53	64
„	Chatteris, The Priory.	..	..	„	Holy Loch, Ardnadam	4·23	107
IV.	Elsenham, Gaunts End	2·83	72	„	Tiree, Cornaigmore	..	..
„	Lexden, Hill House	2·87	73	XVI.	Loch Venachar	3·15	80
„	Aylsham, Rippon Hall	3·30	84	„	Glenquey Reservoir	3·20	81
„	Swaffham	3·30	84	„	Loch Rannoch, Dall	2·24	57
V.	Devizes, Highclere	1·85	47	„	Blair Castle Gardens	1·70	43
„	Weymouth	1·55	39	„	Coupar Angus	1·78	45
„	Ashburton, Druid Ho.	3·81	97	„	Montrose Asylum	2·89	73
„	Cullompton	3·35	85	XVII.	Logie Coldstone, School	2·47	63
„	Hartland Abbey	2·67	68	„	Fyvie Castle	2·41	61
„	Penzance, Morrab Gden.	3·97	101	„	Grantown-on-Spey	1·84	47
„	St. Austell, Trevarna.	3·39	86	XVIII.	Kingussie, Fasnakyle	1·17	30
„	Crewkerne Merefield Ho	2·37	60	„	Fort Augustus	1·57	40
VI.	Clifton College	2·37	60	„	Loch Quoich, Loan	9·10	231
„	Ledbury, Underdown.	2·02	51	„	Fortrose	1·42	36
„	Shifnal, Hatton Grange	2·61	66	„	Faire-na-Squir	..	..
„	Ashbourne, Mayfield.	2·91	74	„	Skye, Dunvegan	3·34	85
„	Barnt Green, Upwood	2·55	65	XIX.	Loch Carron, Plockton.	2·05	52
„	Blockley, Upton Wold	2·57	65	„	Dornoch, St. Gilbert's	2·32	59
VII.	Leicester, TownHallSq.	2·10	53	„	Tongue Manse	2·35	60
„	Grantham, Saltersford	1·43	36	„	Melvich Schoolhouse	..	..
„	Louth, Westgate	2·75	70	XX.	Dunmanway Rectory	4·59	117
„	Mansfield, West Bank	2·62	67	„	Mitchelstown Castle	..	..
VIII.	Nantwich, Dorfold Hall	2·93	74	„	Gearahameen	9·50	241
„	Bolton, Queen's Park.	4·81	122	„	Darrynane Abbey	..	..
„	Lancaster, Strathspey.	4·20	107	„	Cashel, Ballinamona	3·49	89
IX.	Wath-upon-Dearne	2·02	51	„	Roscrea, Timoney Park	2·68	68
„	Bradford, Lister Park.	3·22	82	„	Broadford, Hurdlestown	4·80	122
„	West Witton	5·09	129	XXI.	Kilkenny Castle	3·00	76
„	Scarborough, Scalby	3·15	80	„	Rathnew, Clonmannon	3·10	79
„	Middlesbro', Albert Pk.	2·63	67	„	Hacketstown Rectory	3·71	94
„	Mickleton	..	..	„	Balbriggan, Ardgillan	2·45	62
X.	Bellingham	4·55	116	„	Drogheda	2·49	63
„	Ilderton, Lilburn	3·70	94	„	Athlone, Twyford	..	..
„	Orton	4·31	109	XXII.	Castle Forbes Gdns.	3·57	91
XI.	Llanfrechfa Grange	..	..	„	Ballynahinch Castle	..	..
„	Treherbert, Tyn-y-waun	7·07	180	„	Galway, Grammar Sch.	5·25	133
„	Carmarthen Friary	4·54	115	XXIII.	Westport House	..	..
„	Lampeter, Falcondale	4·30	109	„	Enniskillen, Portora	2·91	74
„	Cray Station	3·90	99	„	Crossdoney Kent Cas.	3·23	82
„	B'ham W.W., Tyrmyndd	4·22	107	„	Armagh Observatory	2·54	65
„	Lake Vyrnwy	4·33	110	„	Warrenpoint	2·91	74
„	Llangynhafal, P. Drâw	2·55	65	„	Belfast, Cave Hill Rd.	2·68	68
„	Oakley Quarries	7·99	203	„	Glenarm Castle	2·98	76
„	Dolgelly, Bryntirion	7·56	192	„	Londonderry, Creggan.	2·78	71
„	Snowdon, Llydaw 10.	14·50	368	„	Sion Mills	2·55	65
„	Lligwy	3·12	79	„	Milford, The Manse	3·03	77
XII.	Stoneykirk, ArdwellHo	3·24	82	„	Narin, Kiltoorish	3·40	86
„	Carsphairn, Shiel	4·04	103	„	Killybegs, Rockmount	5·31	135

Climatological Table for the

STATIONS	PRESSURE		TEMPERATURE							
			Absolute				Mean Values			
	Mean M.S.L.	Diff. from Normal	Max.	Date	Min.	Date	Max.	Min.	½ max. and min.	Diff. from Normal
	mb.	mb.	°F.		°F.		°F.	°F.	°F.	°F.
London, Kew Observatory	1007·9	−6·0	68	14	26	2	50·7	36·9	43·8	−3·5
Gibraltar	1016·9	+1·6	78	26	47	20, 30	70·1	53·5	61·8	+0·5
Malta	1016·0	+3·5	80	28	44	8	67·8	56·5	62·1	+2·4
Sierra Leone	1012·1	+1·1	92	7	71	9	87·7	74·1	80·9	−1·9
Lagos, Nigeria	1010·2	+0·4	90	9	71	2	88·2	75·9	82·1	−0·2
Kaduna, Nigeria	1011·8	+1·1	96	1, 12	63	20	91·3	69·6	80·5	−2·0
Zomba, Nyasaland	1013·2	+1·3	90	29	54	7	79·7	59·4	69·5	+0·2
Salisbury, Rhodesia	1012·5	−1·9	89	3	46	6	82·6	51·9	67·3	+1·4
Cape Town	1017·2	+0·9	102	4	47	12	73·9	54·4	64·1	+1·0
Johannesburg	1017·4	+1·5	80	22	46	19	73·4	52·4	62·9	+3·3
Mauritius	..	..	..	..	..	..	..	..	..	..
Bloemfontein	..	..	85	12	44	14	80·6	50·6	65·6	+4·8
Calcutta, Alipore Obsy.	1006·2	−0·1	103	16	69	9	97·5	77·1	87·3	+1·6
Bombay	1008·1	−0·5	93	25	72	1	90·5	78·6	84·5	+1·4
Madras	1011·0	+2·8	106	22	73	8	93·8	78·2	86·0	+0·7
Colombo, Ceylon	1009·5	+0·4	95	5	71	11	89·5	76·2	82·9	+0·2
Hong Kong	1012·8	+0·2	85	22	61	1	75·7	67·6	71·7	+0·8
Sandakan	..	..	92	30	74	8. 12, 18	87·4	75·8	81·6	−0·6
Sydney	1017·2	−1·2	91	20	53	7	78·1	60·2	69·1	+4·5
Melbourne	1016·7	−2·7	94	17	41	2	70·1	53·2	61·7	+2·2
Adelaide	1017·1	−2·7	93	16	48	5, 8	74·6	57·4	66·0	+2·2
Perth, Western Australia	1016·8	−1·6	95	12	47	30	75·9	55·3	65·6	−0·8
Coolgardie	1015·5	−3·0	97	13	38	30	78·2	54·9	66·5	+1·4
Brisbane	1017·9	+0·5	91	13	58	25	82·3	62·7	72·5	+2·1
Hobart, Tasmania	1011·3	−3·2	84	17	37	25	63·5	47·9	55·7	+0·6
Wellington, N.Z.	1014·9	−2·9	71	20	39	23, 26, 27	64·3	51·1	57·7	+0·9
Suva, Fiji	1009·9	−0·7	88	10	67	28	84·9	69·8	77·3	−1·4
Kingston, Jamaica	1016·2	+1·9	91	15	65	1	87·8	69·6	78·7	+0·3
Grenada, W.I.	1015·4	+2·8	87	22	69	1	83·4	73·1	78·3	−0·5
Toronto	1017·4	+1·9	78	10	25	21	55·0	35·9	45·5	+4·1
Winnipeg	1017·4	+0·4	73	22, 23	17	19	52·3	30·7	41·5	+3·7
St. John, N.B.	1013·6	0·0	60	9	27	6, 23	46·2	32·9	39·5	+0·5
Victoria, B.C.	1020·2	+2·9	67	25	35	12	52·7	40·2	46·5	−1·2

LONDON, KEW OBSERVATORY.—Prevailing wind direction N, mean speed 9·2 mi/hr. 3 days with snow, 2 days with hail, 1 day with thunder heard.

GIBRALTAR.—Prevailing wind direction NW.

MALTA.—Prevailing wind direction WNW. 3 days with hail.

SIERRA LEONE.—Prevailing wind direction SW. 2 days with tornado, 3 days with thunder heard.

LAGOS.—Prevailing wind direction SW.

SALISBURY, RHODESIA.—Prevailing wind direction SE.

COLOMBO, CEYLON.—Prevailing wind direction WSW, mean speed 4·4 mi/hr. 4 days with thunder heard.

British Empire, April 1922.

TEMPERATURE				PRECIPITATION				BRIGHT SUNSHINE		STATIONS
Mean	Absolute	Relative Humidity	Mean Cloud Am'nt	Amount		Diff. from Normal	Days	Hours per day	Percentage of possible	
Wet Bulb.	Min. on Grass									
°F.	°F.	%	0–10	in.	mm.	mm.				
41·1	19	72	6·7	2·60	66	+ 29	15	4·7	34	London, Kew Observatory.
55·5	44	70	2·7	0·13	3	− 65	2	..	..	Gibraltar.
55·9	45	69	4·2	0·11	3	− 17	2	8·7	66	Malta.
73·8	..	67	4·0	4·45	113	+ 10	10	..	..	Sierra Leone.
77·9	69	74	7·5	7·42	188	+ 39	15	..	..	Lagos, Nigeria.
70·1	..	65	1·0	5·24	133	+ 65	7	..	..	Kaduna, Nigeria.
..	..	76	4·1	1·17	30	− 75	7	..	..	Zomba, Nyasaland.
58·6	..	52	1·3	0·00	0	− 26	0	..	..	Salisbury, Rhodesia.
58·4	..	68	5·2	1·12	28	− 23	9	..	..	Cape Town.
50·7	40	56	2·6	0·59	15	− 37	4	9·3	82	Johannesburg.
..	..	..	..	..	..	..	..	..	..	Mauritius.
51·2	..	46	1·9	0·00	0	− 54	0	..	..	Bloemfontein.
76·9	65	46	3·6	1·19	30	− 14	3*	..	..	Calcutta, Alipore Obsy.
77·5	60	69	2·7	0·00	0	− 2	0*	..	..	Bombay.
78·2	69	69	2·3	0·00	0	− 15	0*	..	..	Madras.
78·5	68	66	7·0	8·30	211	− 41	16	..	..	Colombo, Ceylon.
67·1	..	81	7·6	2·02	51	− 89	7	5·1	40	Hong Kong.
77·4	..	87	..	10·64	270	+164	12	..	..	Sandakan.
62·2	47	60	4·5	1·30	33	−105	8	6·5	58	Sydney.
55·8	32	64	6·9	1·39	35	− 22	11	..	..	Melbourne.
57·5	36	56	6·1	1·51	38	− 8	9	4·8	43	Adelaide.
59·7	41	61	3·8	2·71	69	+ 28	5	7·8	69	Perth, Western Australia.
58·9	36	48	5·1	0·94	24	0	5	..	..	Coolgardie.
66·9	47	66	3·0	0·27	7	− 84	4	..	..	Brisbane.
49·9	30	66	6·5	2·01	51	+ 3	16	5·8	53	Hobart, Tasmania.
53·1	27	74	5·8	1·12	28	− 71	12	5·6	51	Wellington, N.Z.
75·3	..	87	6·3	12·41	315	+ 28	17	..	..	Suva, Fiji.
..	..	71	5·3	0·10	3	− 28	2	..	..	Kingston, Jamaica.
72·7	..	71	5·3	1·26	32	− 28	16	..	..	Grenada, W.I.
39·2	19	73	5·0	3·77	96	+ 35	14	..	..	Toronto.
37·7	..	77	4·8	0·52	13	− 25	8	..	..	Winnipeg.
36·1	21	80	6·9	2·49	63	− 26	13	..	..	St. John, N.B.
42·2	27	78	6·3	0·73	19	− 25	8	..	..	Victoria, B.C.

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

HONG KONG.—Prevailing wind direction E, mean speed 12·0 mi/hr. 1 day with thunder heard. 1 day with fog.

SANDAKAN.—Prevailing wind direction NE.

SYDNEY.—Maximum temperatures highest on record for April.

MELBOURNE.—Maximum temperature highest on record for April for 67 years.

PERTH, W.A.—Mean speed of wind 7·1 mi/hr.

WELLINGTON, N.Z.—Prevailing wind direction NNW.

SUVA, FIJI.—Prevailing wind direction easterly.

GRENADA, W.I.—Prevailing wind direction E.

(*Continued from p.* 257.)

A few days later the U.S. liner *Resolute* encountered a cyclonic disturbance in mid-Atlantic, which was stated to have been the worst storm in the captain's knowledge.

On the 21st a very severe hurricane swept the island of Bermuda. The damage to property from the wind, and subsequent abnormal tide, was estimated to reach nearly a quarter of a million sterling, and it is remarkable that only one life appears to have been lost. The hurricane was considered to be the worst one experienced in this island during the last quarter of a century.

A typhoon broke over Chefoo (Shantung) on the 2nd and lasted for 36 hours, but the damage done was not very extensive.

Excellent rains were recorded throughout South Australia during the month and there was every prospect of a really good harvest. The other States also had good rainfalls.

The special message from Brazil states that the distribution of rain in the north and central regions was very irregular, some parts having a fall exceeding the normal and others a deficit. In the southern area the rainfall averaged 39 mm. below normal. Small high pressure areas with very active wind circulations prevailed throughout the month and temperatures were generally high. The state of the crops was satisfactory on the whole.

Rainfall in the British Isles.

DURING the month, roughly half the area of the British Isles received a rainfall below the average. This area was mainly in the centre and south of England, the north coast of Ireland, and included practically the whole of Scotland. The deficiencies were nowhere very large, amounting to more than 40 per cent. only in the Western Highlands. An excess of more than 50 per cent. occurred in Pembrokeshire, Suffolk, and the north-eastern coast of England, and at Newcastle more than twice the average fell. The distribution of the total rainfall of the month over the British Isles was rather more uniform than is usual at the season. Falls of less than 50 mm. (2 in.) occurred mainly in the south of England from London to Yeovil, and in Scotland in the neighbourhood of the Moray Firth and Loch Ness. In eastern Kent falls of more than 100 mm. (4 in.) were widespread, a notable feature of the month. Falls of more than 250 mm. (10 in.) were confined to the English Lake District and Snowdonia.

The general rainfall, expressed as a percentage of the average, was:—England and Wales 123, Scotland 87, Ireland 117, British Isles 110.

In London, Camden Square, the mean temperature for September was 55·5° F., or 2·2° F. below the average.

Duration of rainfall, 37·0 hours; evaporation, 1·11 inch.

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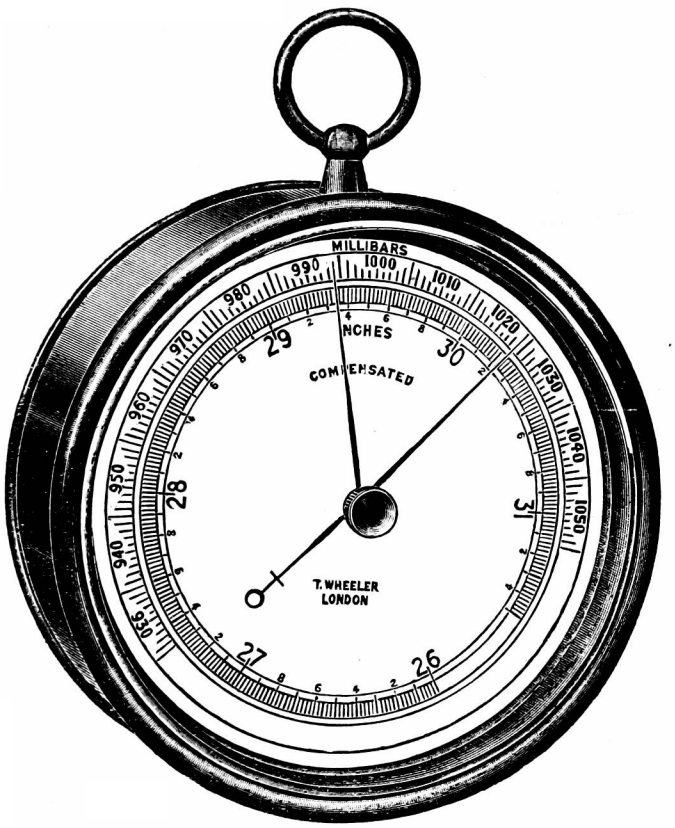

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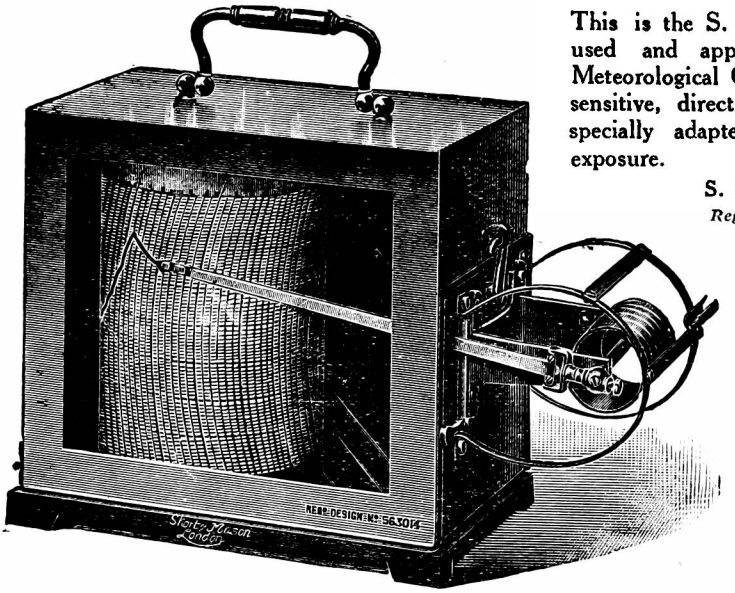

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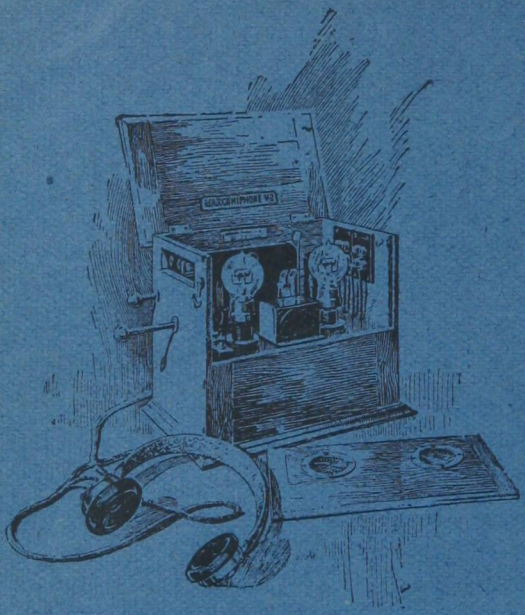

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